Neuropsychologia 91 (2016) 299–306

Contents lists available at ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia

Bilingualism, social cognition and executive functions: A tale of chickens and eggs

Simon R. Cox [a,b,1], Thomas H. Bak [a,b,*,1], Michael Allerhand [a,b], Paul Redmond [a,b], John M. Starr [a,b,c,d], Ian J. Deary [a,b], Sarah E. MacPherson [a,b]

[a] Centre for Cognitive Aging and Cognitive Epidemiology, University of Edinburgh, UK
[b] Department of Psychology, University of Edinburgh, 7 Geroge Square, Edinburgh EH8 9JZ, UK
[c] Geriatric Medicine, University of Edinburgh, UK
[d] Alzheimer Scotland Dementia Research Centre, University of Edinburgh, UK

ARTICLE INFO

Article history:
Received 18 March 2016
Received in revised form
27 August 2016
Accepted 27 August 2016
Available online 29 August 2016

Keywords:
Bilingualism
Executive functions
Social cognition
Childhood intelligence

ABSTRACT

The influence of bilingualism on cognitive functioning is currently a topic of intense scientific debate. The strongest evidence for a cognitive benefit of bilingualism has been demonstrated in executive functions. However, the causal direction of the relationship remains unclear: does learning other languages improve executive functions or are people with better executive abilities more likely to become bilingual?

To address this, we examined 90 male participants of the Lothian Birth Cohort 1936; 26 were bilingual, 64 monolingual. All participants underwent an intelligence test at age 11 years and were assessed on a wide range of executive and social cognition tasks at age 74. The only notable differences between both groups were found for the Simon Effect (which indexes stimulus-response conflict resolution; $\beta = -.518$, $p = 0.025$) and a trend effect for the Faux Pas task (a measure of complex theory of mind; ToM, $\beta = 0.432$, $p = 0.060$). Controlling for the influence of childhood intelligence, parental and own social class significantly attenuated the bilingual advantage on the Faux Pas test ($\beta = 0.058$, $p = 0.816$), whereas the Simon task advantage remained ($\beta = -.589$, $p = 0.049$).

We find some weak evidence that the relationship between bilingualism and cognitive functions may be selective and bi-directional. Pre-existing cognitive and social class differences from childhood may influence both ToM ability in older age and the likelihood of learning another language; yet, bilingualism does not appear to independently contribute to Faux Pas score. Conversely, learning a second language is related to better conflict processing, irrespective of initial childhood ability or social class.

1. Introduction

Whether bilingualism influences cognitive functions beyond language is a subject of intense debate. On one hand, behavioral studies in children (Calvo and Bialystok, 2014; Kapa and Colombo, 2013; Kovács and Mehler, 2009), young adults (Bak et al. 2014a; Vega-Mendoza et al., 2015) and older adults (Bak et al., 2014a,b; Kavé et al., 2008) have reported better performance in bilinguals than monolinguals on certain cognitive tasks, particularly those measuring the ability to ignore conflicting and/or irrelevant information (Bak, 2016a; Bialystok et al., 2004; Costa et al., 2009; Johnson, 1991). Some studies also report differences in visual memory and spatial processing (Kerrigan et al., 2016). Bilinguals have also been reported to develop dementia 4 years later than monolinguals (Alladi et al., 2013; Bialystok et al., 2007; Freedman et al., 2014; Woumans et al., 2015) and to have a better cognitive outcome after stroke (Alladi et al., 2016). The behavioural data are further supported by neuroimaging results, suggesting systematic differences in brain activation between mono- and bilingual subjects (Bialystok et al., 2016).

On the other hand, there are studies involving children (Antón et al., 2014; Duñabeitia et al., 2014; Gathercole et al., 2014), young adults (Paap and Greenberg, 2013) and dementia patients (Yeung et al., 2014; Zahodne et al., 2014), that have not found differences in performance between bilinguals and monolinguals. It has been argued that the evidence supporting the notion of a "bilingual advantage" has been influenced by a publication bias favouring positive results (de Bruin et al., 2015b). An apposite summary of the sceptical view was provided in the title of a recent article: "bilingual advantages in executive functions might either not exist or be restricted to very specific and undetermined circumstances" (Paap et al., 2015).

The act of unconsciously activating two languages is thought to require the selection of the appropriate language and suppression of irrelevant linguistic information which conflicts with the

* Corresponding author at: Department of Psychology, University of Edinburgh, Edinburgh EH8 9JZ, UK.
E-mail address: thomas.bak@ed.ac.uk (T.H. Bak).
[1] Authors contributed equally.

http://dx.doi.org/10.1016/j.neuropsychologia.2016.08.029
0028-3932/

currently activated schema (Costa et al., 2008; Bialystok and Viswanathan, 2009; Green, 2011). Thus, the putative specificity of a bilingual advantage in studies that report significant differences fits intuitively with the theoretical cognitive requirements of bilingualism. It also fits with our understanding of executive functions as heterogeneous and potentially dissociable higher-order control processes (including executive components e.g., Collette et al. (2006), Shallice and Burgess (1996), Baddeley (1996) and the regulation of social behavior e.g., Brazzelli et al. (1994), Eslinger and Damasio (1985) see MacPherson et al. (2015)).

While the debate about the "bilingual advantage" continues, many authors have pointed out that a topic as complex as the interaction between languages and cognitive functions cannot be reduced to a simple "yes" or "no" question (Bak, 2015; Baum and Titone, 2014). Research results can be influenced by a large number of variables, such as the definition of bilingualism, the type of cognitive tasks employed and the populations under study. In terms of the definitions of bilingualism, the previous focus on what was perceived to be a classical case of bilingualism (early, simultaneous acquisition of more than one language), has now been replaced by the insight that "bilinguals differ in ways that matter" (Baum and Titone, 2014, p. 875).

Many recent studies have used a more inclusive definition, based on the ability to communicate rather than a perfect command (Alladi et al., 2013, 2016). Indeed, an improvement in cognitive functions has been reported after only one week of an intensive language course (Bak et al., 2016). Conversely, inactive bilinguals, who used to be early balanced bilinguals in their childhood but moved on to an exclusive use of only one language in their later life, perform differently from active bilinguals and more like monolinguals (de Bruin et al., 2015a, 2016). Moreover, early and late acquisition of another language might have different effects on the cognitive system, with early acquisition favouring switching, late acquisition favouring inhibition tasks (Bak et al., 2014a; Tao et al., 2011). If this is the case, bilingualism research should take into account the interaction between the type of bilingualism and the type of task performed.

Moreover, since most studies compare groups rather than individuals, the question needs to be asked whether the mono- and bilingual populations might differ from each other, not only in their language characteristics but also in other relevant variables (Bak, 2016b). One class of possible confounding variables is that of systematic differences between bi- and monolingual populations, which are difficult to avoid in countries where bilingualism is associated with immigrants and their descendants (Bialystok et al., 2007; Paap and Greenberg, 2013), or where bi- and monolingual participants are recruited from different parts of the same country (Costa et al., 2008, Antón et al., 2014). In such cases, both groups might differ not only in language but also in other influences on cognitive function such as genetics, lifestyle, diet, social structure and education. These types of confounds have been addressed by recent studies, conducted in countries in which knowledge of different languages is not necessarily connected to immigrant status, such as Belgium (Woumans et al., 2015) or India (Bak and Alladi, 2016).

The second type of confound pertains to within-population variability. This problem becomes particularly relevant in studies examining late bilingualism. While early bilingualism is determined to a large extent by parental choice and societal pressures, late bilingualism often reflects the individual's own choice. So why do some people learn other languages and others do not? Here, the crucial issue is that of so-called "reverse causality" or a confusion between cause and consequence (Baum and Titone, 2014): does bilingualism lead to cognitive differences, or do differences in cognitive ability and social class lead some individuals to become bilingual while others not? Such a quandary is similar to the classic causality dilemma: "which came first, the chicken or the egg? ", and is extremely difficult to resolve, since data about cognitive performance and social class prior to second language acquisition are required to determine the causal direction.

The Lothian Birth Cohort 1936 (LBC1936) offers a rare opportunity to tackle several of the above-mentioned problems. Firstly, it comprises individuals born in the same year, mostly growing up and spending most of their lives in the same region of Scotland and all being native English speakers. Secondly, they underwent a well-validated intelligence test in 1947, aged 11 years, and have been extensively characterized in their seventies (Deary et al., 2007, 2012). Thus, we are able to examine potential effects of bilingualism on cognition, accounting for the confounding variables of early life intelligence and social class. The first study examining the effects of bilingualism in this cohort demonstrated that bilinguals performed better than monolinguals, particularly on tests of reading and general intelligence, when controlling for age 11 IQ (Bak et al., 2014b). However, this study used general composite measures of cognitive performance and so was unable to examine effects of bilingualism on specific cognitive tasks, in particular on different aspects of social and executive functions. This question is particularly pertinent to current controversies surrounding the exact type of tasks in which a "bilingualism effect" can be detected. Although, as discussed above, there is a considerable controversy as to whether cognitive differences between monolinguals and bilinguals exist at all, there is a broad consensus that ***if*** such differences exist, they would be found above all in the area of executive functions (Bak, 2016a; Valian, 2015).

Against this background, the present study examines the performance of a subset of 90 LBC1936 participants who – in addition to a measure of cognitive ability age 11, parental and own social class – provided scores on 6 tests at ~age 74 years. The tests were selected to tap a variety of executive and social/emotional abilities: the Simon Task, D-KEFS Tower Test, Self-Ordered Pointing Task (SOPT), Faux Pas test, Moral Dilemmas and Reversal Learning. Until now, such an extensive assessment of older bilinguals using a battery comprising both executive and social/emotional tests has not been conducted. Testing an effect before and after adjusting for childhood cognitive ability and social class offers the rare opportunity to control for possible reverse causation (i.e., better cognitive scores and bilingualism in older age might be related because both arise from having higher childhood intelligence and/or class, rather than because bilingualism benefits cognitive scores).

We hypothesized that bilingualism would confer a selective advantage upon some, but not all cognitive functions examined in our study. Based on the previous literature, the main candidates for potential differences are The Simon Task and the Faux Pas Test. In the former test (which involves the difference in response times for congruent and incongruent items), a bilingual advantage has been reported in the past (Kroll and Bialystok, 2013); these results have been contested by subsequent studies (Paap and Greenberg, 2013; Paap et al., 2015), although the small sample size and large confounds in some of them (Kirk et al., 2014) need to be taken into account when interpreting their findings (Bak, 2015). In the latter test (which measures the ability to accurately identify and describe when a social Faux Pas has been committed in a series of stories), there have been reports of a bilingual advantage on tests of social cognition and theory of mind in children (ToM; Rubio-Fernández and Glucksberg, 2012) but to the best of our knowledge these processes have not been examined in older participants.

In contrast, we expected to find no differences between mono- and bilinguals on the other four tests. Our previous study involving the LBC1936 (Bak et al., 2014b) found no major differences in the Moray House Test, comprising mainly of reasoning tasks and accordingly, we did not expect to find differences on the Tower Test (a test of planning which involves rearranging wooden disks on a 3-peg board to replicate a pictured end-state). Indeed, a recent study conducted in the Hebrides found no difference on the Tower